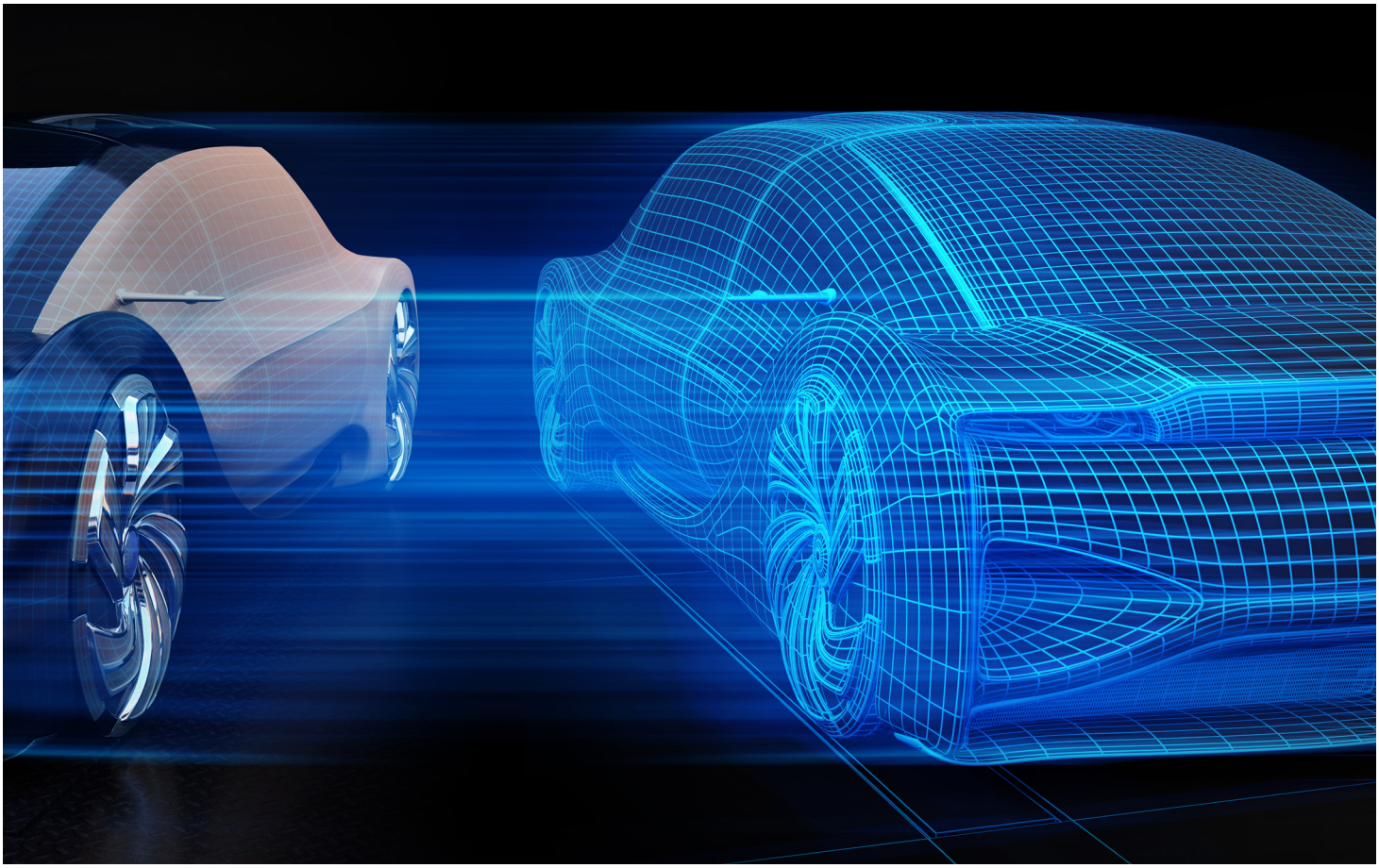


Simplifying 5G with the Network Digital Twin

Introduction

As telecommunications technology transitions from 4G to the incredible promise and potential of 5G, one thing is clear: the new technology is not just an incremental upgrade, but an exponential leap in terms of speed, accuracy, latency and complexity.

Indeed, the complicated nature of 5G is both one of its great advantages—allowing incredible next-generation capabilities in automation, robotics, virtual reality and more—and a huge challenge when it comes to safe, secure, successful implementation.

The many elements that comprise and impact a 5G network or application are constantly and quickly changing. That's largely due to the fact that 5G makes communications and connectivity move much faster than ever before. And, as with any relatively new technology, there are considerable risks and uncertainties. Even 5G standards are still a moving target, fluctuating and evolving along with the emerging industry as a whole. All of these factors add to 5G's complexity.

One undeniable takeaway regarding the implementation of 5G applications and ecosystems is that the traditional ways of testing and assuring are inadequate and need to be augmented with new techniques and processes. Instead of just running tests in a physical lab setting and then performing infrequent reviews with occasional updates after installation, 5G requires testing that is always on and that can implement solutions, whenever needed, in near real-time.

Less complexity and more simplification are what's called for to achieve a less costly and convoluted, more timely and holistic way of approaching the vetting and verification of 5G products, services and applications.

Fortunately, Spirent Communications has answers.

A New Approach to Testing and Assurance

With the advent of 5G, which in many ways is a brand new, very different technology compared to 4G, Spirent has been leading the way in developing solutions for research universities and industries that adopt a fresh approach to testing and service assurance.

As the stakes continue to rise, as more and more investment dollars and valuable partnerships are on the line, these dynamic new testing procedures are vital to moving 5G applications forward. That's why Spirent is working closely with university R&D programs and on/off campus communications projects as well as innovative companies who are embracing 5G and Industry 4.0 to create the smart factories, manufacturing and logistics centers of the future.

Out of the Lab, into the Network

The testing and assurance of 4G and earlier telecommunications technologies typically took place in lab settings, where each procedure was costly in time and money and required careful planning and bundling to effectively manage expenses. Labs are still in use today, but less so because planning, modeling and optimizing 5G in this way is often prohibitively costly and complex.

The technology requires extremely high levels of accuracy, speed and latency that can be difficult to manage. There can be constantly changing problems with signal interference, things moving around and hard surfaces that reflect waves to cause distortions and false readings. There are also issues with capacity and processes being dynamically allocated from the core to the edge and networks becoming virtualized, disaggregated and sliced.

For these reasons, testing and assurance has increasingly moved to automated software that runs via emulation on a copy of the network for which the 5G applications are intended. This allows products and services to be cost-effectively developed, monitored and tested for performance around the clock, and quickly repaired when delays or other problems occur.

Emulation, Not Simulation

Those words—emulation and simulation—seem so alike. There are, however, subtle differences that end up having a profound impact on testing and assurance.

While simulation is a system that behaves similarly to something else (to provide an idea of how something works), emulation behaves exactly like something else. It follows all of the rules of the system being emulated, creating an exact, always-on replica that functions precisely the same way and exhibits the very same characteristics and outcomes.

Through this ability to continuously monitor and deliver reliable results, emulation brings strong advantages—simplicity, cost-effectiveness, repeatability, and predictability—to the testing of complicated real-world network conditions. This, in turn, translates into greater flexibility, convenience, confidence, monetary savings, and momentum for R&D or smart-factory efforts, including the eventual commercial rollout and delivery of 5G products and services.

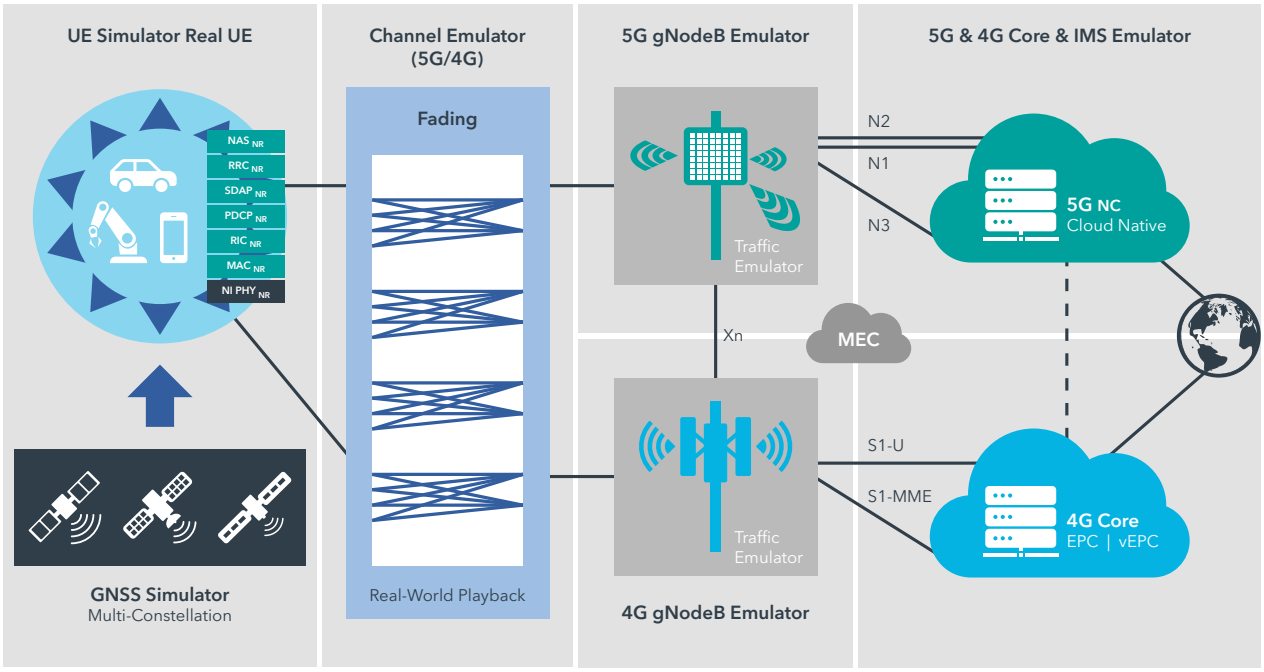
Emulators are used to test both the performance of a real network as well as those network functions and services that are too remote, complex, and costly to easily configure and access. For example, 5G RF Channel modes can be emulated to test a 5G New Radio base-station (gNodeB); a Next-Generation 5G Core network can be emulated to allow for the testing of 5G New Radio.

Get to Know the Digital Twin

The emulated, software replica of the 5G physical network is referred to as the Digital Twin and it allows for continuous prototyping, testing, assuring and self-optimization of the living network. Hardly a new concept, Digital Twins have a history of prior usage in aeronautics, manufacturing and building design to help simulate complex systems. But for 5G, it's still a relatively recent development that's unquestionably groundbreaking.

Although a twin, in real life, doesn't always perform and respond in the same ways as its counterpart, this one does. That consistency allows continuous prototyping, modeling, and research and probably makes it one of the best, most reliable 5G R&D tutors ever.

Through the Digital Twin's multiple emulation processes, traffic and signal generation functions work in harmony to mirror the actual 5G network in every way. Consequently, the physical system's behavior can be tested, analyzed, and then accurately predicted under a nearly infinite set of "what if" possibilities. Better yet, all of this can be accomplished quickly, at low cost and whenever needed.



Always On, Always Working

The Digital Twin enables testing on demand, without interruption, where any aspect of the physical operations system can be examined within the context of any possible situation, i.e. traffic congestion, security breaches or equipment going down. As a result, testing and assurance experts are able to develop new use cases virtually at will and accomplish far more at less cost in time and money than ever before.

The primary emulated components of the 5G Network Digital Twin include:

- **5G Radio Channel Emulation & Sounding–**Emulates new 5G RF channel ranges (sub 6GHz & mmWave), densities, and new RAN technologies (i.e., Massive MIMO, Beamforming). It also emulates the 4G RF for 5G NSA (Non-standalone) scenarios
- **5G gNodeB & 4G eNodeB Emulation–**Emulates 5G & 4G Base Stations with functionality that includes data transfers, mobility control, session management, radio access network sharing, positioning, and functional splits.
- **Fronthaul Emulation–**Emulates next-generation Ethernet fronthaul devices and traffic (i.e., eCPRI, NGFI)
- **Core Network and Cloud Edge Emulation–** Emulates the evolving Core network with the functional disaggregation/separation and distribution to the Edge.
- **Network Slices–**Emulates multiple network slices with different configurations, performance requirements and deployment topologies.
- **Device and Traffic Emulation–**Emulates millions of devices with various types of complex traffic mixes to continuously validate the performance of the network, interfaces and infrastructure.
- **GNSS Simulator–**Simulates satellite constellation signals with complete control over environmental conditions, location, motion, timing and errors.
- **Real-World Emulation–**Recording and playback of real-world captured signals and traffic that are then replicated in a test-bed through emulators for increased realism, repeatability, and predictability.
- **Impairment Emulation–**Emulates network impairments to validate how the network behaves and performs; the insights gained inform how best to compensate via network configuration and architectural adjustments.
- **Security Threat Emulation–**Emulates complex multi-vector attacks that test and audit the 5G environment to pre-emptively identify vulnerabilities and mitigate risks.

Mimicking the Operational Network

The 5G network Digital Twin continues to evolve beyond the lab to become a parallel living system that's part of the operational CI/CD (continuous integration and continuous delivery) environment.

As such, it's poised to become the future of 5G research, development, and service assurance, with some predicting it use as mega-capacity test beds capable of prototyping the performance and security of entire digital economies.

But even now, the system is remarkable considering that any number of test scenarios can be quickly configured, run, optimized and validated through flexible features such as:

- Agile change management verification
- Continuous proactive performance and quality assessments
- Continuous proactive cybersecurity assessments
- Continuous topology optimization assessments
- Rapid fault isolation, triage, and resolution verification

R&D, Campus and Industry Testing on Demand

The Digital Twin simplifies and streamlines 5G testing for university R&D programs and the types of private networks that are now springing up on campuses and in factories, manufacturing and logistics centers worldwide.

When combined with other innovative Spirent solutions such as Lab as a Service with intelligent automation, the Digital Twin represents an ideal testing-on-demand solution.

With significant advantages for modeling and supporting dedicated, next-generation operations, it's rapidly becoming the preferred choice for realizing unified connectivity, optimized services, and secure communications within a specific location, i.e., campus, factory, or geo-fenced area.

Learning the Easy Way

The value proposition for universities is clear. Essentially, the Digital Twin can ease the often costly, time-consuming quest for 5G testing and assurance knowledge through emulation that's capable of running virtually endless test possibilities inexpensively and quickly.

Through the Digital Twin and a complete line of cutting edge, R&D-supporting emulation, automation, test tools and methodologies, Spirent is helping universities:

- Build reputations and establish leadership positions in 5G research and teaching.
- Realize financial sustainability by helping programs and projects qualify and bid for public sector funding and investments, including grants.
- Attract world-class partners from the private sector through joint innovation focused on future 5G-enabled industries.
- Develop commercial opportunities through joint innovation and IPR development.

Revolutionizing Industry

It's fitting that Spirent is offering a revolutionary solution—the world's first 5G network Digital Twin—to help companies compete in Industry 4.0, what many are calling the next industrial revolution.

The beauty of the Digital Twin for manufacturers, manufacturing, and logistics centers is its ability to cost-effectively run tests on any challenge or issue and deliver deployable results without interrupting any networks actually in use. This saves enormous amounts of time, energy, and money by avoiding downtime, delays, and other disruptions.

Additionally, the Digital Twin benefits companies implementing 5G and Industry 4.0 by offsetting and mitigating challenges associated with private and sliced networks such as 5G NR complexity, network validation, and mission-critical KPIs and SLAs.

In use cases for the automotive sector, smart factories, and CSP operations, the Digital Twin is already playing a vital role in transitioning 5G from being a physical network to a living system. These early success stories, in turn, are helping to transform CSP operational cycles and enable future 5G industries to take the factory floor to new levels of heightened connectivity and productivity.

There's also a key role for the Digital Twin to play in mitigating security and privacy risks by providing:

- Continuous assessment of security posture throughout the network
- Realistic emulated security assessment traffic on the exact services you are protecting—so you can assess your security landscape with real attacks, malware, and sensitive data scenarios
- Continuously updated real-world threat intelligence harnessing constantly updated threat intelligence feeds for maximum accuracy.

Digital Twin Use Cases

The Digital Twin is proving its worth in a variety of early applications for automotive drive testing, smart factory configuring, and CSP planning and management. It's estimated that in many of these instances, the Digital Twin's automated, virtual, and emulation capabilities save ten times the amount of time, energy, and money that would otherwise be expended using more traditional means to test and assure. Consider the following:

C-V2X Virtual Drive Testing– Virtual as opposed to real drive tests reduces the number of physical miles required to be driven and enables the modeling of a multitude of complex what-if scenarios and environmental conditions. This is helping Connected Vehicles provide more convenience, safety, and infotainment options than ever before. With the Digital Twin, all aspects of C-V2X connectivity can be tested, refined, and optimized to deliver the experiences that modern drivers and passengers demand.

Private 5G Networks for smart factories–Factories have a complex set of communication requirements (i.e., ultra-low latency, ultra-high reliability, high device synchronicity, time-sensitive networking, ultra-high levels of security and data privacy) and environmental challenges (i.e., surfaces impacting radio propagation, interference, zonal privacy, multi-tenancy). The Digital Twin gives private network operators a cost-effective mechanism to continuously model, plan, optimize, and assure how 5G and ubiquitous connectivity benefits the smart factory.

CSP Network Operations, Planning and Service Quality Management–As networks become virtualized, disaggregated, and sliced, with capacity and processes being dynamically allocated from the core to the edge, attempting to continuously model, optimize, and assure becomes a complex and costly challenge. The Digital Twin of the physical network allows CSP operations teams to continually test, configure and validate how the living network should behave in a safe, secure, non-disruptive, mirroring environment. In addition, the ability to rapidly evaluate optimal configuration and performance options provides a valuable input for network orchestrators to then self-optimize the live network.

About Spirent Communications

Spirent Communications (LSE: SPT) is a global leader with deep expertise and decades of experience in testing, assurance, analytics and security, serving developers, service providers, and enterprise networks.

We help bring clarity to increasingly complex technological and business challenges.

Spirent's customers have made a promise to their customers to deliver superior performance. Spirent assures that those promises are fulfilled.

For more information, visit: www.spirent.com

Imitation Without limitation

For university R&D programs and Industry 4.0 smart factories and manufacturing, the Digital Twin is proving that a network doesn't have to be interrupted or physically rebuilt to test and assure it.

Through automated, software emulation, which goes beyond mere simulation, 5G products, services, and applications are able to be vetted in every conceivable way to ensure actionable results that are realistic, reliable, and repeatable.

Even better, the Digital Twin has the flexible capability to accomplish all of this quickly and cost-effectively in an environment that is safe, private, and secure.

It's a game changing solution for universities in that it simplifies R&D operations, reduces costs, shortens the path to commercial success, and supports an educational leadership role in innovative development and teaching.

For industry in smart factories, manufacturing, and logistics centers, the Digital Twin is by far the simplest to operate, least expensive, and most comprehensive way to configure, test, and assure Industry 4.0 smart factories, federated industrial locations and interconnecting supply chains.

No other testing and assurance system has the ability to securely handle the challenges of total connectivity, low latency, and unprecedented productivity that will come with 5G-related technologies such as AI robotic automation, augmented reality and virtual reality.

Add to that one other crucial factor that makes the Digital Twin the preferred testing and assurance choice: Spirent expertise.

It's that extraordinary level of skill, knowledge, and the ability to work collaboratively with internationally recognized partners such as the National Instruments Corporation that really sets Spirent and the vast capability of the Digital Twin apart.

The aim, overall, is to continue bridging the physical and virtual telecommunications worlds to ensure the seamless, secure, low-cost transmission of verified testing and assurance data and processes.

Whether it's for a university R&D program or an Industry 4.0 smart factory, at the end of the day, you promise your key stakeholders to make 5G a viable, productive, profitable reality. Spirent is here to simplify and ensure that success.

Spirent. Promise. Assured.

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Promise. Assured.

Contact Us

For more information, call your Spirent sales representative or visit us on the web at www.spirent.com/ContactSpirent.

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